Space Weather Technical Forecast

Issued on Saturday, 24 February 2024 at 13:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares expected with a chance of X-flares, and slight chance of associated solar radiation storms. Chance of G1/Minor geomagnetic storm mainly day 2 (25 Feb).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with seven M-flares observed, all from AR3590 and peaking M4.5 at 24/0634 UTC. There are five numbered spots, however AR3590 remains the largest region on the disc, by far. Despite its size and activity, the complexity of the region remains relatively limited. Growth of a negative polarity intermediate spot has resulted in this forming a delta spot with the strong positive polarity leader, however this delta spot remains weak due to only limited flux along the polarity inversion line. Much smaller and also weak delta spots have persisted on the periphery of the region, and the overall areal extent of the region continues to gradually increase. The other regions are much smaller and simpler, with no significant growth observed.

There were no Earth directed CMEs observed.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, have been indicative of the slow wind. Speeds have been at background 300-350 km/s. Density was average or below. Total Interplanetary Magnetic field (IMF) strength, Bt, was weak, below 7nT, with the north-south component showing periods of weak positive (northward) field, peaking +6nT and weak negative (southward) field with minimum -5nT. Phi angle was mainly negative (towards from the Sun), but with some variability. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was very slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold. Electron flux (greater than 2MeV) observed at GOES16 has been at normal background levels, with electron fluence well below the Active (1e8 integrated pfu) threshold. The observed 24-hour fluence at 24/0000UTC was 1.0e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to remain Moderate to High, with occasional M-class flares expected and a chance of further isolated X-class flares from AR3590.

Solar Wind / Geomagnetic Activity: CME from the filament eruption on 21 Feb may giving a glancing impact later on day 1 or early day 2 (24-25 Feb). Background solar winds are likely to become enhanced day 2, from the onset of the fast wind from CH01/-, before peaking into day 3 (25-26 Feb). These fast winds easing day 4 (27 Feb). Quiet activity at first becoming Unsettled to Active with a chance of G1 Minor Storms from any coronal hole fast wind onset, or any CME glance that occurs. These most likely day 2 (25 Feb), if any combined arrival occurs. Quiet to Unsettled activity returning day 4 (27 Feb).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is likely to continue easing near background levels, but with a chance of enhancement due to any significant flares from AR3590, increasing from day 2 (25 Feb) due to the region moving west into the western hemisphere. High energy electron flux (greater than 2MeV) is expected to persist at background at first. An increase to Moderate or High levels is then possible later in

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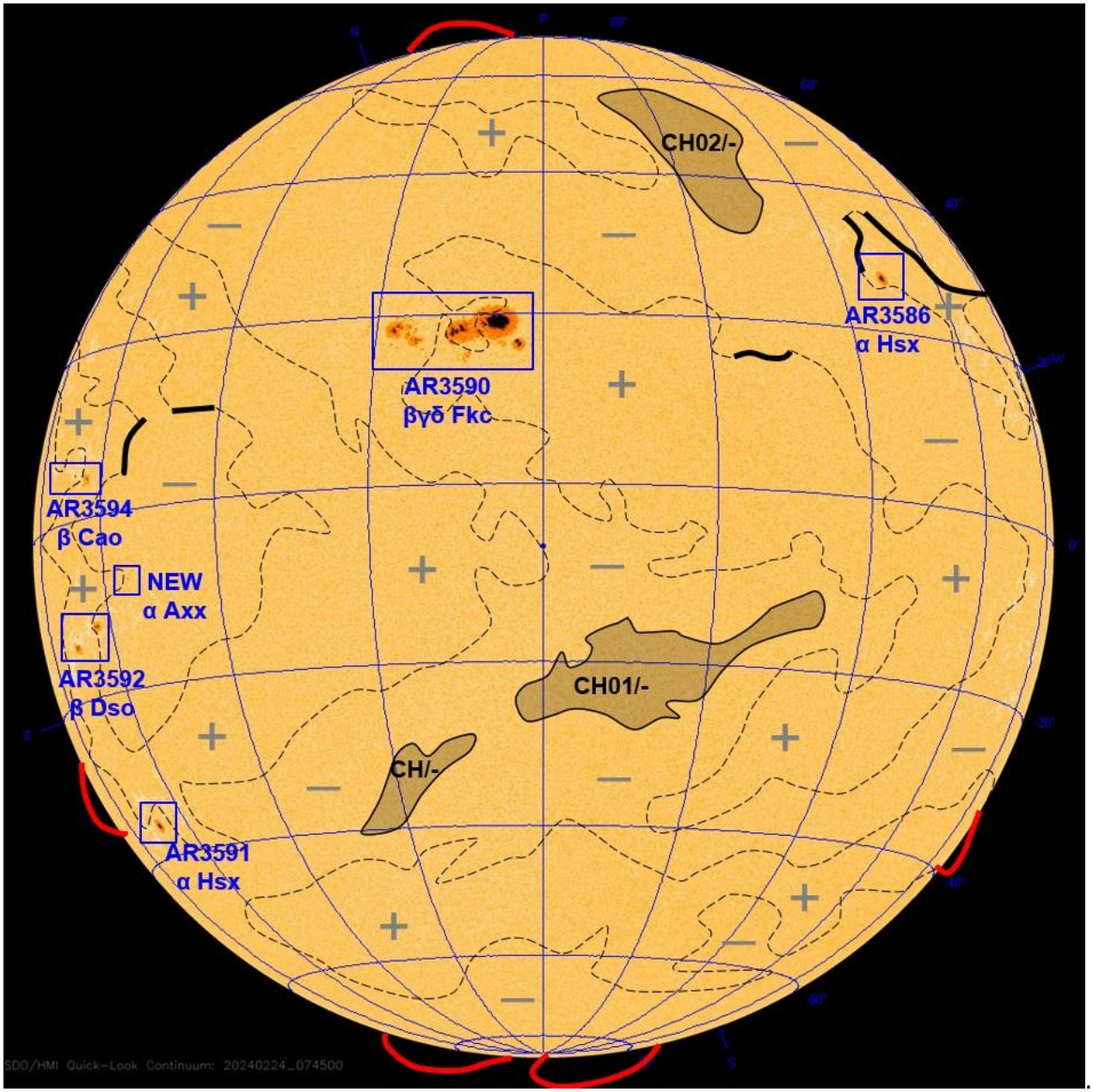
day 3 (26 Feb) onward in response to any solar wind enhancement from the CME or coronal hole fast wind onset. 24-hour electron fluence is expected to stay below the Active (1e8 integrated pfu) threshold, but with a rising trend, giving a slight chance of reaching Active by day 4 (27 Feb).

Figure 1. Solar Analysis Valid 24/0800 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one CME with a potential Earth-directed component. This was from a large filament eruption from the northwest disc around 21/1730UTC. This is expected to pass 1AU late on Day 1 (24 Feb) or early on Day 2 (25 Feb), with a glancing impact possible.

Background solar winds are expected through day 1 (24 Feb), before likely becoming slightly enhanced day 2 (25 Feb) due to the onset of the fast wind originating from the western extension of CH01/-. This is portion of the coronal hole is similar to the previous rotation, where only a muted response was observed, however the persistence of this coronal hole, alongside the potential CME glance will bring a likelihood of Unsettled to Active geomagnetic activity with a chance of G1 Minor Storm intervals day 2 (25 Feb). This risk is further increased due to the proximity of the March equinox (Russel-McPherron effect). This enhancement is also supported by MOSWOC Enlil.

The western portion of CH01/- is larger and darker on this rotation however, suggesting a more prolonged enhancement than MOSWOC enlil currently indicates. The fastest portion of the HSS is most likely to be observed later day 2 or day 3 (25-26 Feb), with solar winds potentially peaking 550-600km/s. This will bring an ongoing slight chance of Active to G1 Minor Storm intervals, before easing day 4 (27 Feb) onward.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/0145 UTC	Partial	Filament	NW	540 km/s	25/0300 UTC +/- 9hrs	Glancing impact

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Figure 2a: MOSWOC Enlil and Ensemble

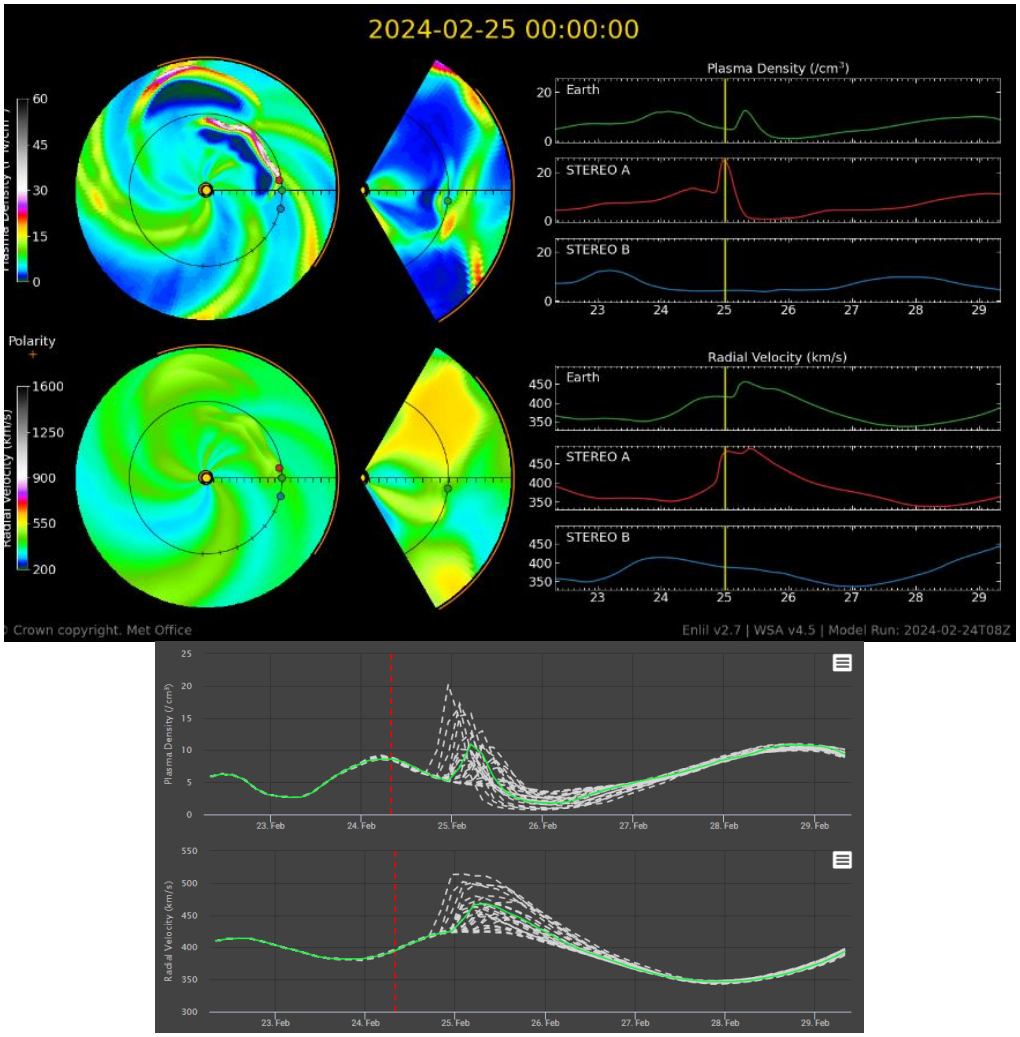
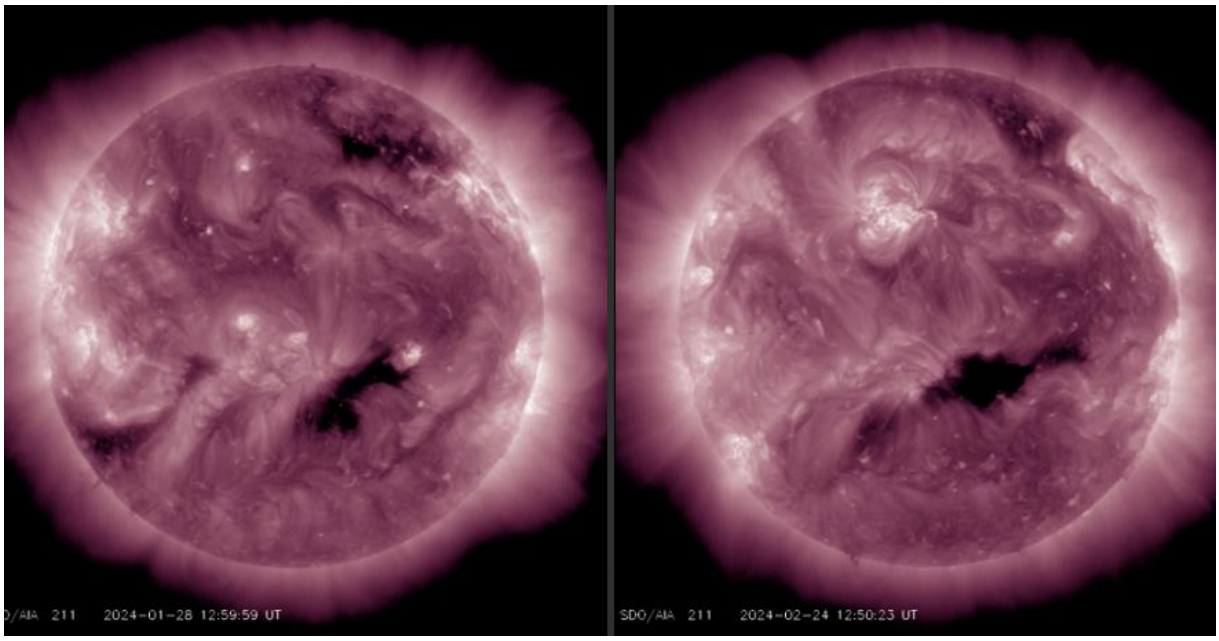


Figure 2b: SDO aia-211 of current and previous rotation.



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Radio Blackouts - X-Ray Flares:

Moderate to High activity is expected, with further M-flares and a chance of isolated X-class flares from AR3590.

This is a large sunspot in the north-centre disc, and was the source of three X-class flares, including an X6.3 on 22 Feb that was the largest of SC25 so far. Despite its large size the spot itself lacks some of the usual expected features of such an active region, including a strong delta spot. However, weak delta spots are evident, along with some large looping in SDO imagery. Growth of an intermediate spot has also resulted in this spot being incorporated into a single large penumbra with the main large opposite polarity leader spot. This has also resulted in a large delta spot, but with only relatively weak flux near its magnetic inversion line. However, this main leader also has a strong magnetic flux associated with it, increasing the potential for strong flares.

There are a number of other small spots on the disc, giving six total regions, however these are all weaker and in the absence of any notable growth are likely to be limited to giving a risk of very isolated M-flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	75	70	60
Very Active	R3 to R5 X Class	No	30	25	20	15

Figure 3: GOES-16/18 X-ray Flux

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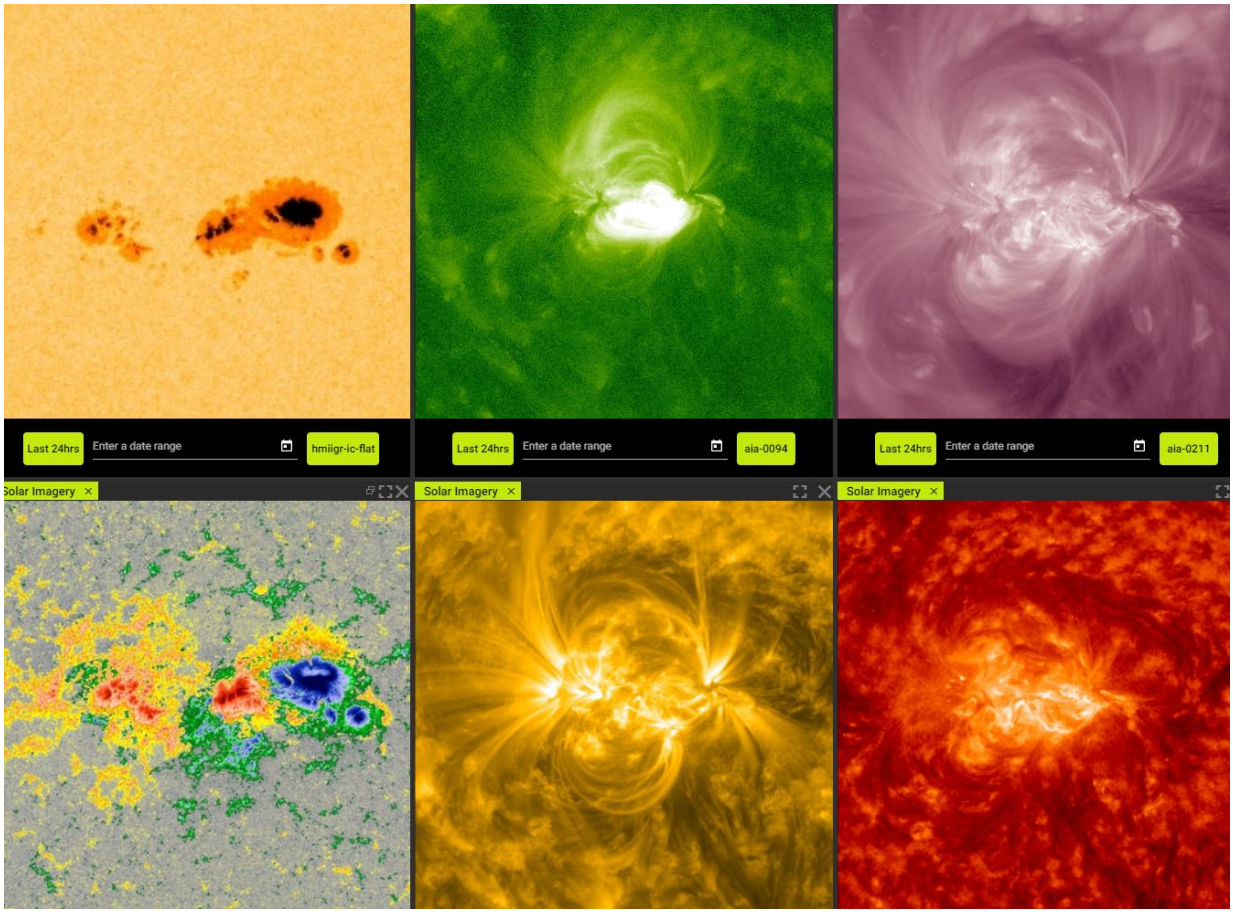
Figure 4: SDO imagery of AR3590 (Top: Intensitygram, aia-094, aia-211 Bottom: Magnetogram, aia-171, aia-304)



Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold. The source of this slight enhancement is only moderate confidence, but most likely due to the lingering effects of the increased flux since 09 Feb. The X-flares of AR3590 are unlikely to have contributed.

However, as AR3590 moves into the western disc any further strong flare activity will bring a chance of enhancing the observed proton flux at GEO, especially if those flares are eruptive. This will bring a chance of reaching S1 Minor Radiation storm levels, with a slight chance of stronger storms being observed (S2+).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	20	25	25
Very Active	**≥ S3 ***	No	1	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is currently at background. The expected enhancement from CH01/- and the potential glancing CME arrival are likely to increase populations through the Van Allen Belts, however confidence is low with how strong this enhancement will be. Initially observed at lower orbits, any enhanced flux will relax back to GEO through day 3 and day 4 (26-27 Feb), with the observed GOES-16 flux likely becoming Moderate with a chance of reaching High.

The associated 24 fluence is expected to remain below the Active (1e8 integrated pfu) threshold during much of this period, but with a possible rising trend later in the period. This will give a slight chance of reaching Active by the end of day 4 (27 Feb). MOSWOC REFM is showing a below Active trend through the next three days, and will give good guidance in the absence of any coronal hole soured fast wind or CME enhancement.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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